EDITORIAL ARTICLES.

ON THE PRESENT STATE OF KNOWLEDGE IN BACTERIAL SCIENCE IN ITS SURGICAL RELATIONS.

(Continued from Page 226.)

C. SEPSIS.

Septic diseases were among the first to awaken interest in the part played by micro-organisms in disease, and it is, no doubt, due to this fact, that more has been written on subjects relating to septicæmia than on any other subject of bacterial interest in surgery. During the years 1872 to 1874 alone, more than forty original researches on sepsis and pyæmia were published, and some of them by men like Billroth and Virchow. And yet at the present time the subject is by no means fully elucidated, and it is not even possible to give a general definition of the term septicæmia, which could correctly represent all the different conceptions of its nature current at the present time.

Generally speaking, the term septicæmia has of late years been used to designate such febrile disorders accompanying a more or less inflamed (but not necessarily putrid) condition of wounds, in which no metastatic suppurations occurred, and in which, indeed, the autopsy furnished only negative results to the naked eye. The term pyæmia, on the other hand, was applied whenever metastatic abscesses or suppurative processes occurred independently in different parts of the body, whether a wound was present or not. Whether rigors occurred, as in true progressive (thrombo-phlebitic) pyæmia, or not, as in simple metastatic or chronic pyæmia, was only a question of secondary importance to the pathologist. But the general infection occurring in some cases of osteomyelitis was nevertheless spoken of as septicæmia, and metastases were not infrequently spoken of in connection with septicæmia.

Some writers, in fact, claimed the difference between septicæmia and pyæmia to be only a quantitative one, consisting, on the one side, in a gradual, on the other, in a sudden and copious introduction of infective agents into the system, while others maintained that pyæmia was a specific disease *sui generis*, as much so as acute articular rheumatism, and that it was in no wise related to sepsis, where the infectious matter showed no specific tendencies. Again, some authors identified septic and putrid processes, while others distinguished between them.

One point of analogy between the two diseases, however, lies in the fact that micro-organisms have been found present in both. Rindfleisch, as long ago as 1866, found micro-organisms in myocarditic abscesses, and von Recklinghausen, Waldeyer (1871), Klebs and Hüter were the pioneers of our knowledge of septic diseases; the first mentioned first describing the bacteria found in abscesses, while the appearance of Klebs' treatise[1] marked a new era in the bacteriology of septic diseases. In this work the writer identified septicæmia and pyæmia, qualitatively speaking, although he believed putrid and septic infectious processes to be the same.

By this time septicæmia had been also experimentally produced in animals, first by Magendie, whose work was not published, however, and soon after, in 1872, by Cozé and Feltz[2] and by Davaine[3], whose names are best known in this connection.

These authors were able to produce the disease by injecting putrefying substances into the circulation, and could not only demonstrate the presence of bacteria in the blood of the animals, but could inoculate any number of others from each inoculated individual. Examination of the blood of the animals after death constantly revealed numberless bacteria in each drop of blood.

Soon, however, v. Bergmann[4] was able, by purely chemical processes, to produce out of putrefying blood, a crystallizing substance, "sepsin," perfectly free from any micro-organisms, which, when injected into the circulation of animals, caused death with septicæmic symptoms; and, later on, Hiller[1] was able to produce similar affections with ferments, and E. v. Bergmann and Angerer[2], by injecting pepsin and pancreatin into the blood could occasion all the symptoms characteristic of septicæmic poisoning, such as, in man, is marked by fever, headache, pains in the back and limbs, general weakness, comatose condition, disturbed sleep, dry coated tongue, loss of appetite, impaired digestion, thirst, gastric disturbance, icterus, failing of the heart's action, tumor of the spleen and lymphatic glands.

---

[1] Beiträge zur pathol. Anatomie der Schusswunden. Leipzig. 1872.

[2] Recherches expérimentales sur la présence des infusoirs . . . dans les maladies infectieuses. Strassbourg. 1866.

[3] Bulletin de l'Academie de med. 2 sér. 1872.

[4] Das putride Gift, etc. Dorpat. 1866. *Deutsch. Zeitschr. f. Chir.*, I., 373. 1872. *Med. Centralblatt.* 1868. 397.

The most diverse theories were furthermore put forward to explain the action of the bacteria found in septic diseases. While some authors maintained that the bacteria were themselves the essential cause of all disturbance, others believed that the micro-organisms *per se* were harmless, but that they produced some alkaloid virus (ptomaïne) which was the sole cause of disease, and others considered them capable of some destructive action upon the blood, thus causing disintegration of the blood-elements and occasioning disease by analogy of ferment-poisoning.

In fact, so great did the general confusion of opinion become, that when, even in the year 1881, E. Semmer, of Dorpat[3], undertook to review the state of knowledge of septic infections at that time, he could do so only by classifying the authors under different headings. He divided them all into two large groups, (1) those who experimented with putrid matter on the healthy animal body, without any regard to micro-organisms, which group comprises twenty-nine names, among them Virchow, Billroth, Bergmann, Schmiedeberg and Schmidt; and (2) those who paid special attention to the presence of micro-organisms. The latter group is much the larger, and includes four subdivisions, without counting those authors like Cagniard, Latour, Schwann, Helmholtz, Schulze, Schrœder, Dusch, Pasteur, Hallier, who had previously called attention to the fact that putrefaction was due to micro-organisms.

---

[1] *Centrabl. f. Chir.* 1876. Die Lehre von der Fäulniss. Berlin. 1879.

[2] Das Verhältniss der Fermentintoxication zur Septicæmie. *Festscrift.* Separata druck. Leipzig. 1882.

[3] *Virchow's Archiv.* Vol. 83, 99. Jan. 1881.

The first subdivision (a) consists of authors who attached no importance to the presence of micro-organisms: Panum and Bergmann. He then (b) enumerates those who deny their influence, Panum, Ravitzsch, Billroth, Hiller, Küssner, Wolff, Eberth, Orth, Tillmans, Dougall, Satterthwaite, Curtis, Anders. (c) The followers of theories ascribing to bacteria etiological importance in the causation of disease are Cozé, Feltz, Greveler, Hüter, Birch-Hirschfeld, Puky, Brehm, Klebs, Tiegel, Kehrer, Sanderson, Landau, Schüller, Bergmann. Another (d) group consists of authors who experimented by inoculating with the blood of animals first rendered diseased. Here again we have two factions, on the one side those opposed to theories investing bacteria with etiological importance, Clementi, Thin, Colin, Dreyer, Laborde, Hiller, Ravitsch, Bouley. On the other side those advocating these theories, Cozé, Feltz, Semmer, Davaine; endorsed by Sanderson, Klein, Vulpian, Leblanc, Colin, Stricker, Clementi, Dreyer, Koch, Gutmann. To this latter group belong Pasteur, Joubert, Chamberlain, who differentiate between putrid and septicæmic infections, and also Chomäkow, who believes the septic poison to be affixed to the micrococci.

Meanwhile some of the subtler questions in regard to the conduct of the micro-organisms were being solved by incessant experiments.

Koch, in his classic work on the infectious diseases of wounds,[1] had demonstrated two distinct varieties of septicæmia, one in mice, the other in rabbits (improving on Pasteur's former demonstrations by means of his new methods of staining, etc.). In fifty-four mice he found bacilli 1 μ in length and 0.1 μ in breadth, which developed inside of the white blood-corpuscles and were set free when these became destroyed, and could then be seen in the capillaries, though they were not to be found in the lymph ducts and serous cavities. In rabbits he found large oval micrococci floating in the capillaries. From these experiments he first deduced the theorem of the stability of species of the pathogenic organisms.

But the results of the authors mentioned above, Davaine, Cozé and Feltz, taken together with the theories of Naegeli and Wernich, who believed that all micro-organisms could vary their character by a sort of evolutionary process and adapt themselves to the media in which they had to live—tended to show that the virulence of the bacteria was progressive, in such a manner that when inoculation was performed from one animal to another in successive so-called generations, one drop of blood of a later generation was much more poisonous in its effects than the same quantity taken from an earlier generation. Thus Davaine could cause rapid septicæmic death in a rabbit by injecting a single drop of a mixture prepared by adding to a quantity of blood of a rabbit, which had died inoculated in the twenty-fourth generation, *one trillion times* its quantity of pure water.

---

[1] Wundinfectionskrankheiten. Leipzig. 1878.

Although these results are not compatible with Koch's tenets regarding the permanence of species, yet so many various experimentators had arrived at similar results with Davaine, that Birch-Hirschfeld, reviewing the matter in *Schmidt's Jahrbücher der gesammten Medicin*, in 1875, had concluded from the evidence then existing that there could be no doubt as to the correctness of the theory of progressive virulence in septicæmia.

In order to throw some light on these conflicting statements Gaffky, of the Prussian army, assisting in Koch's laboratory, undertook the task of investigating Davaine's septicæmia[1]. He procured the infection by using water from a stagnant river, and, by continually controlling his experiments with the microscope, using Koch's methods, and working only with pure cultures, he was able to prove beyond a doubt that the theories of progressive virulence of bacteria were untenable. He was enabled, by using pure cultures for inoculation, to attain the highest possible degree of virulence already in the second generation; this result was achieved as soon as the blood itself represented a pure culture of the microbe. The tenet was therefore established, that pathogenic bacteria are specific beings, which can only originate from and bring forth their own peculiar species, gifted, as such, with unchangeable attributes.

Purely putrid infection, on the other hand, in which a chemical substance causes poisoning, cannot, it was shown, be imparted from one animal to another by inoculation of minute quantities of blood.

---

[1] Experimentell erzeugte Septicæmie, etc. Mittheil. a. d. Kaiserl. Gesundheitsamte. Vol. I. 80.

Although a new epoch was introduced into bacteriology by the establishment of Koch's school, one of the features of which is represented by Gaffky's paper, other publications with different aims still continued, for a time, to appear. Rosenberger,[1] who, after producing Davaine's and Pasteur's septicæmia (the latter the so-called malignant œdema of Koch) sterilized the blood containing the micro-organisms, but was nevertheless able to produce the characteristic disease, together with the characteristic micro-organisms by injecting this sterilized fluid into healthy animals, was led to believe that the poison existing in septicæmic blood had the property of converting harmless bacteria, which he consequently supposed to exist in healthy tissues, into specific pathogenic ones.

Zweifel[2] also concluded from his experiments that bacteria were harmless, unless they were deprived of oxygen, in which case they produced a poison deleterious to the system. His experiments had tended to prove that oxygenized blood would not become putrid, although micrococci were present. but that deoxygenized blood readily turned putrid; highly oxygenized blood, moreover, when injected into the abdominal cavity of animals, did not cause septic peritonitis, whereas deoxygenized blood always did.

The influence of oxygen on the development of certain micro-organisms was first pointed out by Pasteur.

Rossbach found that papayotin, when injected into the circulation of animals, soon caused numerous micro-organisms to appear in the blood, which observation he explained by the supposition that micro-organisms were prevented in some way from developing in healthy blood, until aided by the action of the ferment.

Meanwhile other investigators continued the researches in other directions. Ziemacki[3] repeated the experiments of von Recklinghausen, etc., and searched the organs of eighteen cases of phlegmons, abscesses, puerperal fever, etc., for micrococci. He found them situated in the capillaries, where they could be developed into colonies by keeping the organs in a moist atmosphere at a temperature of 35° C. for twenty-four hours. He could not produce similar colonies in cadavers which had not been previously subjected to septic infection.

---

[1] Ueber das wesen des septischen Giftes. Leipzig. F. C. W. Vogel. 1882.

[2] Untersuchung über die Entstehung des sept. Gifts, etc. *Zeitschr. für Physiol. Chemis.* Vol. VI. Hft. 4 and 5.

[3] Beitrag zur Kentniss der Micrococcencolonien in den Blutgefässen bei sept. Erkrankungen. *Prager Zeitschr. f. Heilkunde.* Vol. 4. 89.

Brieger[1], Maas[2] and others continued the experiments of chemical extraction of ptomaïnes, following the researches of Thiersch, v. Bergmann, Panum, Samuel, Hiller, so that the literature on this subject soon became very extensive, and the fact of putrid intoxication by ptomaïnes became well established.

Thus on the one side, sufficient evidence was acquired that chemical substances can produce septic symptoms; but, on the other hand, the evidence is continually growing with the extension of Koch's school, that bacteria are present in septic diseases, and that no bacteria are present in healthy tissues. But the question as to what part the bacteria actually play in the disease, whether their effect is due to some specific action or qualities, either mechanical or chemical, of their own, or to some poisonous substance, which they produce, or to the destruction of some substance which they consume, still remains open. The conclusion that septicæmia in man is due to the presence of micrococci in the blood, is, as we have seen, to a great extent drawn from analogy with the experimental septicæmia in animals. Now, it might be objected that we were not justified in admitting the conclusion. But Garré[3] has recently furnished some experiments quite analogous to those of Gaffky. Inoculating his own person *lege artis* and with antiseptic precautions with pure cultures of the organisms found by the most approved authorities to be most frequently present in septic diseases (*staph. pyog. aur.*), he was able to produce not only local symptoms of suppuration, but general symptoms resembling those of septicæmia, fever, sleeplessness, etc., although, as the author admits, the infection was not as serious in all cases as might be scientifically desirable.

These experiments, however slight they may appear in value, are of much greater importance than the occasional infections of wounds occurring in daily surgical practice, with instruments, etc., because they were performed with pure cultures and with suitable precautions.

---

[1] Giftige Producte der Fäul.-Bakt. *Berl. Klin. Woch. Schrift.* 1884. No. 14. *Zeitschrift f. physiol. Chem.* 1884. VIII. Hft. 4. *Berichte d. deutsch. Chem. Ges.* 1884. XVII. 215.

[2] Ueber Fäulniss-Alcaloide. *Fortschritte der Med.* 1883. No. 11, 473, *with review*; 1884. No. 22. 729. *Arch. f. klin. Chir.* Vol. 29. Hft. 3. 1883.

[3] *Fortschritte der Medicin.* Vol. 3, 165. No. 6. March 15.

But even if it be conceded that septicæmia can be transmitted by inoculation from man to man, it cannot be denied that the analogy between the experimental septicæmia of Davaine in animals and the disease usually designated by the term septicæmia in man is incomplete. In the first place, the micro-organisms procurable by culture-experiments from the blood of both are not the same. This fact, however, is not surprising, since we know that septic diseases in mice and in rabbits also differ in the species of germs present, and only necessitates a broader definition of the term.

In the second place, however, the number of micro-organisms present in septicæmic blood of man is so small that it is frequently impossible to obtain pure cultures by inoculation of soils with such blood, whereas, on the other hand, the number of bacteria to be seen in the blood of rabbits rendered septicæmic by experiment is so great that it appears sufficient to cause death simply by mechanical means.

It therefore seems natural to suppose that the micro-organisms of septicæmia are capable of producing some poisonous substance which kills the patient before the micro-organisms have sufficient time to multiply to the extent that the septic micro-organisms do in rabbits or in mice, or that other species of micro-organisms, as those of anthrax, do in man.

Prof. Neelsen, of Rostock, pointed out this difference in a paper read before the thirteenth Congress of German surgeons at Berlin[1]. He suggested the name of *acute mycosis of the blood* for those diseases where the blood-vessels appear crowded with micro-cocci before death. He believes these micro-organisms only prove fatal in great numbers because the virus is in some way fixed to them, and can only become potent if they greatly multiply. The other line of diseases, on the contrary, where, as in septicæmia, death occurs when only comparatively few micro-organisms are to be found before death, he would have called *toxic mycoses of the blood*, and believes the poison generated by the micro-organisms to be soluble in the blood and fluids of the body, and thus capable of acting independently of the microbes themselves and at a greater distance.

---

[1] See report. Berlin, April, 1884. "Wie lassen sich die klin. Begriffe Septhæmie," etc.

Neelsen, however, believes septicæmia in man to be far more complex in its nature than the last described disease, and believes that it is a combination of a putrid infection by ptomaïnes[1], with some such toxic mycosis of the blood as above described, necessitating the circulation of some micro-organisms capable of producing poison in the blood. In fact, he distinguishes three separate elements in septicæmia, the presence of some pyogenic or pus-forming organism being essential to the combination, as well as the other two component elements. These pyogenic germs would, according to his view, produce suppuration, either at the seat of the wound or at some more distant point, whither they might have been transported by the lymph or blood-current. Such cases should then be correctly termed septicæmia with lymphatic or phlebitic metastases, respectively.

Neelsen, it should here be remarked, considers pyæmia a specific disease of an entirely different nature, occasioned by the action of micro-organisms gifted with the power of resisting the effects of the blood-current (so destructive to many kinds of organisms) and with the peculiar ability of leaving the blood-course and of establishing themselves at other points in the tissues, here to produce suppuration. The latter virtue distinguishes them from the organisms of toxic mycoses, which never leave the blood-vessels, though they are likewise capable of resisting the deleterious effects of the blood-current.

In support of his theory, the author argues that neither those micro-organisms which produce acute mycoses of the blood, nor those which produce toxic mycoses show any signs of putrefactive action when cultivated alone, though the latter assertion still requires further proof.

Again, it is not the germs of putrefaction themselves which produce symptoms of putrid intoxication, since these micro-organisms are very soon killed, when once introduced into the blood-current, but only their chemical poison, when absorbed. And even when putrid poisons (ptomaïnes) are absorbed, there must be several different kinds simultaneously absorbed in order to produce the complete set of symptoms found in septicæmia, since the injection of any one of the known ptomaïnes alone, even of Bergmann's sepsin, is not sufficient to produce the entire complex. It is essential to the clinical picture of true intoxication with putrid virus, that none of the five symptoms, fever, vomiting, profuse diarrhœa, somnolence, increasing failure of the heart's action, be absent, and this can only be the case when a combination of several different kinds of putrid virus is absorbed. As regards this latter question, it may be remembered that Prof. Blumberg, of Kasan —and this brings us to the latest publications on this general subject— concluded from his numerous experiments on animals[1] that the symptoms of inoculation with putrescent material very considerably vary, that in fact extreme asthenia, heightened temperature, acceleration of the pulse and respiration-rate, are the only constant symptoms found.

---

[1] Probably by absorption from the wound.

Blumberg also confirmed the statement that the blood of animals dying from putrid intoxication contained no micro-organisms, and Fränkel,[2] who had found but few micrococci in the blood of septicæmic patients and observed that they greatly increased shortly after death, but after lapse of some further time, altogether disappeared, thus also confirmed a fact previously known, that putrefaction destroyed septic germs.

The general impression produced upon the discriminating observer by the present aspect of the whole subject under consideration, then, is that *septicæmia is probably due to the action of bacteria in the blood producing some poison analogous to the known ptomaïnes*—which is a view expressed by Koch.[3]

The next step towards a more complete knowledge of the disease would call for a more exact bacteriological description of the kinds of micro-organisms found in the blood, and an extensive series of chemical experiments analyzing the special ptomaïnes produced by each separate species of these microbes, as heretofore ptomaïnes have generally been extracted only from putrescent material containing all varieties of micro-organisms at once. Physiological experiments testing their action upon animals will then help to complete this programme.

---

[1] *Virchow's Archives.* June 8, 1885. Vol. 100. Hft. 3.

[2] Ueber Micro-org. der chir. Infections Krankheiten. *Wiener Med. Wochschrift.* 1885. XXXV. 108, 141, 173.

[3] Wundinfections Krankheiten.

The isolation and special study of the septic bacteria is going on at the present time and has become fairly advanced.

Rosenbach, of Goettingen, in his book on the micro-organisms found in infectious diseases of wounds[1] published a description of the bacteria found in septic diseases.

In three cases of septicæmia which he examined, he found the *staphylococcus pyogenes aureus* present each time in suppurations in the tissues; in two of the cases he found an organism of putrefactive quality present in the secretion of the wound (*bacillus saprogenes No. 3*). In two of the cases no cultures could be procured from the blood. In two cases of gangrene, with general septicæmic symptoms, *streptococcus pyogenes* was found throughout.

Intoxication with putrid matter he believes due to the presence of three distinct species of bacilli, which he terms *bacillus saprogenes No. 1, 2, 3*, respectively. No. 1 he cultivated from putrescent blood, and this he believes to be comparatively harmless. No. 2, facetiously termed "*Bacillus Scheidemanni*,"because it was found to be the cause of the disagreeable odor of the foot-perspiration of a patient of that name, he characterizes as "invasive," pus-forming, but probably not toxic. No. 3, having the same properties, was found in a complicated fracture which had become putrid. The patient subsequently died and *staph. pyo. aur.* was found in the metastases.

Rosenbach, however, it must be borne in mind, takes a somewhat exceptional view of sepsis, and appears to combine the idea of a fœtid condition of the wounds and offensive discharge with the term sepsis, making no sufficiently clear distinction between septicæmia and sapræmia. He moreover hints that perhaps the true micro-organism of septicæmia is not yet found.

Passet,[2] who did not attempt any culture-experiments with blood of septicæmic patients, cultivated eight kinds of micro-organisms from various unopened phlegmons and abscesses of a septic (not putrid) ture, the most frequent forms of which were identical with those described by Rosenbach. With these he succeeded in producing more or less marked results upon animals, many of whom died with symptoms resembling septicæmia.

---

[1] Wiesbaden. 1884.

[2] Untersuchungen über die Aetiologie der eitrigen Phlegmone des Menschen. Berlin. 1885. *Fischer's Verl.*

The characteristics of the micro-organisms described by Passet (staphylococcus pyogenes, albus, aureus and citreus; streptococcus; pseudo-pneumo-coccus; staphylococcus cereus albus and flavus; Bacillus pyogenes fœtidus), have recently been given in this journal. (Vide ANNALS OF SURGERY, Jan., 1886, p. 71 et seq.).

Physiologically considered, all the species have an extensive existence. The streptococci live about three months; the others, however, are easily inoculated after a lapse of six months, the staphylococci even after twelve months. Dried up specimens were inoculable after ten days. Cold (+4° C.) prevents their growth, but does not destroy them. Temperature of boiling water destroys them. The gelatine was only liquefied by the staphylococci, most likely, in the opinion of the author, by means of the formation of peptone.[1]

The principal forms of these micro-organisms, the staph. aur. and alb., were found by Rosenbach and Garré in acute osteomyelitis, and by the latter coursing in the blood—a fact interesting in so far as it throws a certain light upon the clinical observation that septicæmia frequently occurs in acute osteomyelitic disease.

Garré also confirmed Passet's results as regards septic affections of the tissues (unopened abscesses, furunculi, phlegmons, whitlows, etc.), examining seventy-two cases in all, and forty-eight of these with Koch's culture-methods. In forty-five of the latter and sixty-eight of the former he found staph. aur. Strept. pyog. he found only in four causes of phlegmoné.

We possess also a very interesting paper on the results of examinations made of human milk, by Escherich, of Vienna[2], which bears upon the present subject.

After assuring himself by the examination with suitable methods of twenty-five healthy cases that normal milk contained no micro-organisms, he investigated the milk of such patients whose bodily temperature was elevated by reason of disturbances in the puerperal process or lactation, who, in fact, presented more or less severe septic disorders; and here he regularly found micrococci present in the milk, principally staphylococci, aureus and albus.

---

[1] If this latter were an established fact it would give rise to interesting theories regarding septicæmia, especially when taken together with the physiologcial fact that peptone prevents fibrin-coagulation in the blood.

[2] *Fortschritte der Medicin.* Vol. 3, 231. No. 8. April. 1885.

In the cases of such *puerperæ* who had fever from other causes, such as pulmonary phthisis, otitis media, etc., no micro-organisms were found in the milk.

Escherich believes that the micro-organisms are introduced into the milk through the blood, which they enter, in puerperal septicæmia, through wounds of the genital tract.

From these strictly bacteriological investigations it would seem that the real cause of septicæmic disorders were the staphylococci, and that the other species were more of local importance. The bacilli, on the other hand, appear more closely connected with sapræmia and putrid processes.

W. W. Van Arsdale.

THE IMPORTANCE OF EXAMINING THE RECTUM DIGITALLY IN CASES OF INTESTINAL OBSTRUCTION.

The importance of always examining the rectum digitally in cases of intestinal obstruction is well exemplified in a case reported by M. Trélat in the *Gazette des Hôpitaux*, for October 27, 1885.

In his report M. Trélat makes some criticisms which can hardly be pleasant reading for the colleague under whose care the patient was placed.

Briefly, the facts occurred as follows:

On the 13th of September a man of 51 years of age was admitted into the Charité with a swollen tympanitic abdomen, neither wind nor fæces having passed for five days.

The previous history was that eight years ago he had an *attack of vomiting, diarrhœa, marked emaciation* and *loss of strength.* Then followed eight years of good health till four months ago, when a similar attack seized him and caused him to enter the Charité under M. Bernutz for a week, when he improved sufficiently to be able to re-